Effects of physiological age on residual feed intake of growing heifers

Andrea N. Loyd, Charles R. Long, Andrew W. Lewis, Ronald D. Randel*

Texas AgriLife Research, Overton, TX, USA; *Corresponding Author: r-randel@tamu.edu

Received 22 July 2011; revised 6 September 2011; accepted 20 September 2011.

ABSTRACT

Using a retrospective evaluation of feed efficiency, this study investigated the effects of physiological age on residual feed intake (RFI) in growing heifers. Data were collected during 1973 and 1974 at the McGregor location of the Texas Agricultural Experiment Station. Heifers (n = 77) were obtained from a large crossbreeding program utilizing a five-breed diallel mating scheme using Angus, Brahman, Hereford, Holstein and Jersey breeds. At approximately 6 months of age, pre-pubertal heifers were individually penned and received ad libitum access to a balanced diet. Individual feed intake and body weight data were collected at 28-day intervals for 84 days prior to puberty and for 90 days after puberty. The diet was changed at puberty to provide a lower energy density. Considering all females as cohorts, RFI was calculated for each heifer for each period using separate models for the pre- and post-pubertal periods. A moderate, positive Pearson correlation (r = 0.48; P < 0.001) was detected between pre- and post-pubertal RFI. Furthermore, heifer RFI rank was compared between the pre- and post-pubertal periods using Spearman rank order correlation and a similar correlation (r = 0.46; P < 0.001) was revealed. This suggests that RFI determined during the pre-pubertal period may only be a moderate predictor of post-pubertal RFI. As a result, physiological age should be considered when evaluating cattle for feed efficiency using RFI.

Keywords: Cattle; Puberty; Residual Feed Intake

1. INTRODUCTION

Feed provided to cattle represents a significant portion of the cost of producing beef [1]. Identifying and selecting cattle that are more efficient at utilizing feed resources can potentially reduce feed usage. Selection strategies for improving feed efficiency have been shifting away from the conventionally used feed:gain ratio (FG) and are incorporating residual feed intake (RFI) as an indicator of feed efficiency in beef cattle. Many variables can influence the outcome of an RFI evaluation; however, many of these factors can be controlled (i.e. test duration, type and amount of diet provided, selection of cohorts of animals, etc.). The Beef Improvement Federation (BIF) has developed guidelines to standardize the methodology for RFI evaluation [2]. Specific to cohort selection, it is recommended that cattle be at least 240 days of age and not differ by more than 60 days of age at the beginning of an RFI feeding trial [2]. Although cattle may be of similar chronological age, they may differ in physiological maturity since an important biological phenomenon (puberty) may occur during this time in bulls and heifers.

Brody (1945) suggested that puberty coincides with the inflection point of the growth curve, which corresponds to a shift in body composition away from lean accrual and towards fat deposition. Recent studies suggest that differences in body composition may contribute to differences in RFI [4-7]. Since gonadal steroids associated with puberty alter body composition, pre-pubertal RFI may differ from post-pubertal RFI. The objective of this study was to investigate the potential consequences of cohort selection, specifically physiological age, on the outcomes of RFI evaluations. To accomplish our objective, RFI was evaluated on heifers during two distinct stages of development (pre- and post-puberty).

Since the expense associated with RFI research is substantial, this study was conducted using feed intake (FI) and body weight (BW) data previously collected from heifers pre- and post-puberty. The FI and BW data were initially reported as a component of an experiment [8,9] that did not include RFI analysis. The current study made use of these historical data to bring new information to RFI research.

Furthermore, there are currently very few research initiatives investigating feed efficiency of replacement
heifers. Most studies use steers and terminal heifers when evaluating various facets of RFI and feed efficiency [10-13]. Therefore, this study provides unique and relevant RFI data pertaining specifically to heifers that will be retained in the cowherd.

2. MATERIALS AND METHODS

2.1. Animals and Experimental Design

Data used for this study were collected during 1973 and 1974 from the McGregor location of the Texas Agricultural Experiment Station as previously described [8,9]. Heifers (n = 77) were obtained from a large cross-breeding program that utilized a five-breed diallel mating scheme. Heifer breeds included straightbred Angus (n = 7), Brahman (n = 5), Hereford (n = 5), Holstein (n = 6) and Jersey (n = 5) and F1 Angus × Brahman (n = 3), Angus × Hereford (n = 4), Angus × Holstein (n = 4), Angus × Jersey (n = 5), Brahman × Hereford (n = 6), Brahman × Holstein (n = 6), Brahman × Jersey (n = 6), Hereford × Holstein (n = 5), Hereford × Jersey (n = 5) and Holstein × Jersey (n = 5) crosses (reciprocals pooled). Pre-pubertal heifers were individually penned at approximately 6 months of age in 3 m by 10 m open, dirt-floored pens and were allowed ad libitum access to a balanced diet. After reaching puberty, the diet was changed for each heifer to reduce energy density ([17]. Furthermore, recent results suggest that feeding cattle receiving ad libitum access to feed in groups using GrowSafe® [12] or Insentec [13,16] electronic feeding equipment. Current BIF guidelines suggest that feed intake data obtained from individually-penned cattle are inadequate [2]. However, the initial concept of RFI was published using data from cattle fed in individual pens [17]. Furthermore, recent results suggest that feeding cattle in individual pens yields similar results to group-feeding cattle as long as the cattle are stimulated to come to the bunk more than once daily [18]. In our study, such, a separate model was fitted for each period to determine pre- and post-pubertal RFI. All heifers were considered as cohorts for each of the pre- and post-pubertal RFI calculations. Initial BW and average daily gain (ADG) of each period were computed from linear regression of BW on day of test using the PROC REG function of SAS (2002). Mid-test BW was estimated for each period using the intercept and slope from the regression and adjusting for 3% shrink. Metabolic mid-test BW (MMBW) was calculated as mid-test BW$^{0.75}$ for each period. Expected daily FI was predicted for each period by linear regression of average daily feed intake (ADFI) on MMBW and ADG using the GLM procedure of SAS (2002). The model fitted for each period was

$$Y_i = \beta_0 + \beta_1 \text{MMBW}_i + \beta_2 \text{ADG}_i,$$  

where $Y_i =$ expected daily feed intake, $\beta_0 =$ the regression intercept, $\beta_1 =$ the partial regression coefficient of FI on MMBW, and $\beta_2 =$ the partial regression coefficient of FI on ADG. Residual feed intake was computed for each heifer for each period by subtracting actual feed intake from expected feed intake.

2.3. Statistical Analysis

Pearson correlation coefficients were determined using the PROC CORR function of SAS (2002) to correlate pre- and post-pubertal RFI. Spearman rank order correlation was used to evaluate changes in heifer RFI rank from the pre- to post-pubertal periods [15].

3. RESULTS AND DISCUSSION

Age, BW, ADG, ADFI, and RFI summary statistics are presented in Table 2. As expected age, BW and ADFI were greater for the post-pubertal period than for the pre-pubertal period. Average daily gain was reduced in the post-pubertal period, likely as a result of the decreased energy density of the diet. By definition, mean RFI was 0.00 kg/day for both the pre- and post-pubertal periods. The range between the most efficient and least efficient heifers was 2.79 kg/day for the pre-pubertal period. Average daily gain was reduced in the post-pubertal period, likely as a result of the decreased energy density of the diet. By definition, mean RFI was 0.00 kg/day for both the pre- and post-pubertal periods. The range between the most efficient and least efficient heifers was 2.79 kg/day for the pre-pubertal period and 6.04 kg/day for the post-pubertal period. Despite these heifers being individually fed, this range is consistent with previous reports of RFI for growing cattle receiving ad libitum access to feed in groups using GrowSafe® [12] or Insentec [13,16] electronic feeding equipment. Current BIF guidelines suggest that feed intake data obtained from individually-penned cattle are inadequate [2]. However, the initial concept of RFI was published using data from cattle fed in individual pens [17]. Furthermore, recent results suggest that feeding cattle in individual pens yields similar results to group-feeding cattle as long as the cattle are stimulated to come to the bunk more than once daily [18]. In our study,
Table 2. Pre- and post-pubertal summary statistics for growing heifers (n = 77).

<table>
<thead>
<tr>
<th>Trait</th>
<th>Pre-pubertal</th>
<th>Post-pubertal</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
</tr>
<tr>
<td>Initial age, months</td>
<td>5.6</td>
<td>0.6</td>
</tr>
<tr>
<td>Age at puberty, months</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Test duration, days</td>
<td>84</td>
<td>6</td>
</tr>
<tr>
<td>Initial BW, kg</td>
<td>116.1</td>
<td>25.7</td>
</tr>
<tr>
<td>Final BW, kg</td>
<td>196.0</td>
<td>33.7</td>
</tr>
<tr>
<td>MMBW, kg</td>
<td>43.0</td>
<td>6.1</td>
</tr>
<tr>
<td>ADG, kg/day</td>
<td>0.95</td>
<td>0.17</td>
</tr>
<tr>
<td>ADFI, kg/day</td>
<td>6.0</td>
<td>1.0</td>
</tr>
<tr>
<td>RFI, kg/day</td>
<td>0.00</td>
<td>0.57</td>
</tr>
</tbody>
</table>

1BW = body weight; MMBW = metabolic mid-test body weight; ADG = average daily gain; ADFI = average daily feed intake; RFI = residual feed intake; SD = standard deviation; Min = minimum; Max = maximum.

As cattle grow, composition of their gain shifts from protein accretion to fat deposition [23]. Since the energetic expense associated with protein accrual is less than for fat deposition [24], the efficiency with which cattle convert feed into BW gain is reduced as they mature. A substantial shift from protein accretion towards adipose deposition occurs around the time of puberty [3]. These changes in body composition associated with advancing physiological maturity could partially explain the moderate correlations between pre- and post-pubertal RFI reported in this study. This suggests that RFI determined during the pre-pubertal period may be only a moderate predictor of feed efficiency during the post-pubertal period.

Admittedly, it is not possible to separate the effects of puberty status from the effects of the diet change from the pre-pubertal to the post-pubertal feeding periods in the current study. To definitively attribute differences in pre-pubertal and post-pubertal RFI, the same diet would have to have been fed throughout the experiment. As this is a retrospective analysis of previously collected data, this could not be controlled. Nonetheless, previous experiments that have evaluated RFI on cattle fed the same diet at different ages observed similar correlations as reported here [10,19]. As a result, physiological maturity should be considered when selecting cohorts of cattle for RFI evaluation.

REFERENCES


